Characterization Equipment for Electrooptics and Actuators

Final Report

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Introduction

The goal of the ONR sponsored grant entitled "Characterization Equipment for Electrooptics and Actuators" is to enhance the characterization capabilities of the Electroceramic Group in the Ceramics Department of Clemson University in the areas of electrooptics and electromechanical actuators. These are core research areas, so the instrumentation acquired through this grant benefits the majority of current research projects. This report summarizes research which directly benefits from the acquired instrumentation.

The new equipment strengthens dielectric, piezoelectric, and electrooptic characterization capabilities for both thin film and bulk devices. Dielectric and piezoelectric characterization of materials is especially useful in current studies of actuator devices such as Rainbow devices. Electrooptic characterization equipment is used mainly to study transparent PLZT thin film ceramics.

Funding for the equipment was cost shared between ONR and Clemson University. Clemson provided $50,000 of matching funds for the equipment with the remaining $56,031 coming from ONR.

The impact of the new equipment on electrooptic research is outlined in section I, and on actuator research in section II. References are listed in Section III. Appendix 1 lists the equipment acquired through this grant.

I. Electrooptics

Two instruments were purchased for electrooptic characterization with the grant. These instruments are 1) Prism Coupler, Model 2010, Metricon Corporation; 2) Ultraviolet Source, Model Maxima 100, Spectronics Corporation.

The Prism Coupler is capable of simultaneously determining the index of refraction and thickness of thin film materials. Since its purchase, it has been used to perform desired optical characterization of thin film materials. The index of refraction of ferroelectric films on silicon substrates and its dispersion were determined using the prism coupler. Antiferroelectric thin films on silicon substrates and indium-tin oxide thin films were also characterized using the instrument. These characterizations have been essential in carrying out some of our research, particularly in ferroelectric thin film devices[1,2].

The Ultraviolet Source has been used in the study of the photo-assisted antiferroelectric-to-ferroelectric phase transition in thin film materials. Near-ultraviolet radiation is brought conveniently to thin film samples through a flexible

fluid-filled light guide. Recent results of such study have shown great promise for antiferroelectric thin films to be used as a medium for optical recording and holography[1].

A 5302 EG&G Lock-in amplifier is used in the birefringence measurements, which rely on the phase-sensitive signals. .

II. Actuators

Two instruments were purchased for dielectric and piezoelectric characterization of thin films and bulk devices with the grant. These instruments are 1) HP 4194A Impedance Analyzer; 2) HP 4284A Capacitance Bridge. A ZMI-1000 interferometer was acquired for the study of the field-induced displacements over a wide range of frequencies and displacements.

The Impedance Analyzer greatly simplifies characterization of the piezoelectric properties of Rainbow devices. Its continuous frequency sweep mode enables the simultaneous determination of all major resonant modes in a specified frequency range. The HP 4194 has frequency range of 100 Hz to 40 MHz which is well suited for characterization of these materials. The investigation of the resonance properties of Rainbow devices resulted in the identification and characterization of low frequency bending modes. Different mechanical boundary conditions were shown to have a much greater effect on the bending modes as compared to the radial modes. The experimentally observed resonance modes are in good agreement with those predicted by Finite Element Modeling[3].

The HP 4194A Impedance Analyzer was also used extensively in the investigation of PLZT 2/55/45 and $PbZrO_3$ ferroelectric/antiferroelectric thin film composite structures with 2-2 connectivity. These films were studied as a function of frequency and applied DC bias. The results indicate that the dielectric constants for the composite films were increased compared to those for pure $PbZrO_3$. The double hystereses loops for the composite films were squarer and better saturated. High frequency measurements of the dielectric constant enhanced understanding of substrate/film interfaces[4].

The HP 4284A Precision LCR Meter is used mainly for the low frequency determination of the dielectric constant of both thin film and bulk devices. It has higher measurement precision and range extending to lower frequencies (minimum 20 Hz) than the HP 4194A.

The ZMI-1000 Interferometer, manufactured by Zygo Corporation, is used to characterize field-induced displacements of the Rainbow devices. It is a single axis linear displacement interferometer with 133 KHz acquisition rate and 2.5

nanometer resolution. It extended actuator characterization to smaller displacements and higher frequency. Rainbow devices were characterized with the driving voltages in a wide range of frequencies and amplitudes. The low frequency, high drive characterization of Rainbow devices indicated that theses devices are capable of very large displacements[5].

The RT66A Hysteresis looper from Radiant Technologies is being used on a routine basis for characterization of the thin film hystereses loops.

III. References

1. F. Wang, K. K. Li and G. H. Haertling, "Photo-Activated Phase Transition in Antiferroelectric Thin Films for Optical Switching and Data Storage," Proc. of the OSA topical meeting: Optical Data Storage, Dana Point, CA, May 16-18, 1994, in press.

2. F. Wang and G. H. Haertling, "Large Electrooptic Modulation Using Ferroelectric Thin Films in a Fabry-Perot Cavity," presented in the 9th International Symposium on the Applications of Ferroelectrics, University Park, PA, August 7-10, 1994.

3. E. Furman, G. Li and G. H. Haertling, "An Investigation of the Resonant Properties of Rainbow Devices," accepted for publication in *Ferroelectrics*.

4. D. E. Dausch, F. Wang and G. H. Haertling, "Antiferroelectric/Ferroelectric Composite Thin Films," presented in the 9th International Symposium on the Applications of Ferroelectrics, University Park, PA, August 7-10, 1994.

5. E. Furman, G. Li and G. Haertling, "Electromechanical Properties of Rainbow Devices," presented in the 9th International Symposium on the Applications of Ferroelectrics, University Park, PA, August 7-10, 1994.

IV. Appendix

Listing of major equipment ordered:

Instrument	Manufacturer
Prism Coupler, Model 2010	Metricon Corporation
5302 Lock-in Amplifier	EG&G
Maxima 100 Ultraviolet Source	Spectronics Corporation
HP 4194A Impedance Analyzer	Hewlett-Packard
HP 4284A Precision LCR Meter	Hewlett-Packard
ZMI-1000 Interferometer	Zygo Corporation
RT 66A Standardized Ferroelectric Test System	Radiant Technologies, Inc.